# Propagation Model Development & Comparisons

### Outputs

- Improvement of the effective height algorithm in the ITS Irregular Terrain Model (ITM).

The propagation model development effort continued the focus on improvements to the algorithm for determining the effective antenna heights within the ITS Irregular Terrain Model (ITM) in its point-to-point mode. The effective antenna heights determine a number of important intermediate quantities that are very influential in the prediction of the computed reference attenuation in the ITM, notably the smooth earth horizon distances and, in the case of line-of-sight paths, the radio horizon distances and horizon elevation angles. In the ITM, the sum of the smooth earth horizon distances determines the point at which the line-of-sight range attenuation curve is matched to the diffraction range attenuation curve. The radio horizon distances and elevation angles are used, among other things, to determine the values of the attenuation curve in the diffraction range. For any given transhorizon path, frequency of operation and polarization, higher effective heights will tend to yield less predicted attenuation than lower effective heights. For "short" line-of-sight paths and moderately flat terrain, however, there is the possibility of constructive and destructive interference between the direct ray and the ray reflected from the ground as the dominant propagation mechanism, so reduction in attenuation is not necessarily strictly monotonic with increasing effective heights.

For transhorizon paths the direct ray between the terminals' structural heights does not clear the intervening terrain, so the radio horizon distances and horizon elevation angles are determined from the highest visible (as seen from each terminal's structural height in the direction of the geodesic between the terminals) terrain point (for single horizon paths) or points (for double horizon paths) on the terrain profile between the terminals. For line-of-sight paths the direct ray between the terminals' structural heights clears the intervening terrain, so these quantities are undefined. To circumvent this difficulty, the ITM algorithm falls back to the method used in its area prediction mode, that is, the radio horizon distances and elevation angles are set empirically, using the observed medians of these quantities. The observed median radio horizon distances are monotonically increasing functions of the effective heights, and the observed median horizon elevation angles are monotonically decreasing functions of the radio horizon distances.

In the area prediction mode of the ITM, the path distance is a parameter. In contrast, in the point-to-point mode of the ITM, the path distance is a given for the path in question. Therefore, to complete the definition of the radio horizon distances and elevation angles for line-of-sight paths in the point-to-point mode, the sum of the radio horizon distances is compared to the path distance. If this sum is less than the path distance, which implies that the path is transhorizon, as opposed to line-of-sight, then the effective heights are increased by a factor designed to increase the sum to be just greater than or equal to the path distance. That is, it is assumed that the original estimates of the effective heights were too low for the inferred radio horizon distances to be consistent with the line-of-sight category and that, in consequence, these effective heights should be increased. In this instance, the radio horizon distances and elevation angles are also recomputed, based on the increased effective heights.

Figures 1 and 2 illustrate the differences in the ITM's predictions between two methods of estimating the effective antenna heights. Figure 1 shows predicted field strengths (dB μV/m) using the current ITM point-to-point mode algorithm for estimating the effective antenna heights around a notional transmitter site near Denver, Colorado. Figure 2 shows the same predicted field strength levels as Figure 1 for the same site, but with the effective antenna heights fixed at the structural heights, regardless of the comparison between the sum of the inferred radio horizon distances and the path distance. A comparison of the two figures reveals that fixing the effective heights at the structural heights yields a more conservative prediction. This result is not too surprising, since the current ITM algorithm for estimating the effective antenna heights always yields estimates that are greater than or equal to the structural heights.

During the previous year's effort, it was evident that considerable accuracy improvement over the current algorithm could be obtained for transhorizon paths, if one were to locate and fit the terrain in the vicinity of the point(s) of minimum Fresnel clearance on the terminal's immediate foreground (i.e., the terrain between the terminal in question and its radio horizon) and extrapolate that fit to the terminal's location. Unfortunately, this approach was not nearly so fruitful when applied to the full terrain profile on line-of-sight paths. One possible reason for this is the close coupling between the effective heights and the radio horizon distances and elevation angles for line-of-sight paths.

In order to overcome this coupling for line-of-sight paths, some method of determining the radio horizon distances and elevation angles on these paths is required. If one uses the same definition for these quantities that is applied to transhorizon paths, but extends the terrain which is considered to the geodesic beyond the terminals, then it is clear that these always exist. Furthermore, the sum of these radio horizon distances will always be greater than or equal to the path distance. This modification to the line-of-sight algorithm has been implemented and some initial testing/comparison to measured propagation data has been carried out. The results are encouraging, but it is expected that some additional refinements to the effective height algorithm will yield further predictive accuracy improvements.

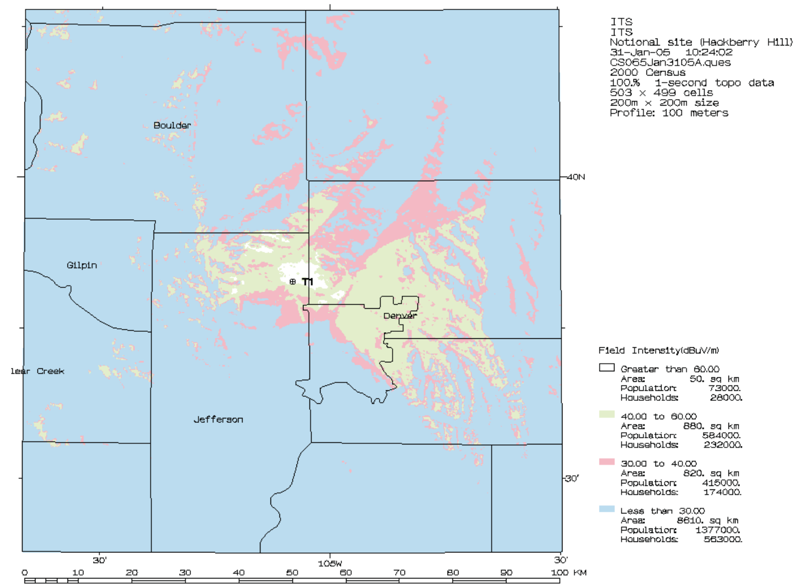


*Figure 1. Communication System Performance Model (CSPM) plot showing predicted radio coverage using ITM with the existing effective height algorithm.*

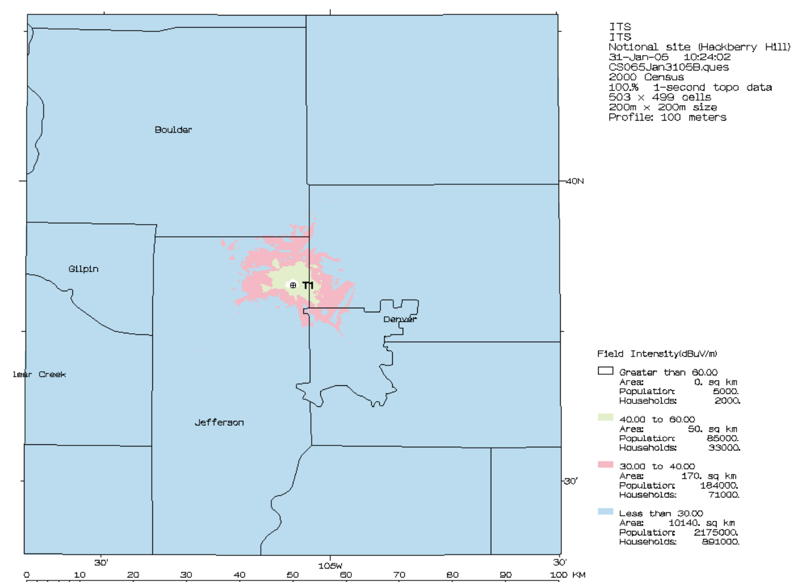


*Figure 2. CSPM plot showing predicted radio coverage using ITM with effective heights set to the structured height above ground.*

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